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IN THE UNITED STATES PATENT OFFICE

Honorable Commissioner of Patents
Washington, D.C.

Re: Applicant: JEROME H. LEMELSON
Ser. No: 449,074 [illegible]
Filed: July 28, 1954
For: AUTOMATIC PRODUCTION SYSTEM
Div. 4

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October 13, 1961

Dear Sir:

In the above identified application, it is desired to file a divisional application under Rule 147.

Accordingly, please prepare a certified copy of the original application, as filed, and prepare and mount prints of those seven drawings originally filed which pertain to the elected invention, e.g. all original drawings with the exception of those containing Figs. 24-26, Figs. 27-29 and Fig. 25' and not including the last 3 sheets of drawings submitted with paper # 16.

A check for $ 70.00 is enclosed herewith which is believed to more than amply cover fees for the above and the filing fee.

There is filed herewith an amendment cancelling all the claims not pertaining to the elected invention e.g. Group I specified on pages 1 and 3 of paper #3 of the parent case.

It is applicant's understanding that the filing date of the divisional application will be that on which this request is received.

It is also requested that a print be made of the page ~~containing claim 25 of the original application~~ [illegible] illustrating Figs. 22 and 25 and that these and all future correspondences be mailed to applicant at: 8B Garfield Apartments Metuchen, New Jersey.

Respectfully submitted,
Jerome H. Lemelson
Jerome H. Lemelson
Applicant

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The conventional multiple machine set-up or transfer machine is designed to perform specific operations on a single product. It is inflexible and quite often not capable of working on any product or item other than that which it is designed for. If changes in set-up can be made, they are costly as they require considerable labor, tedious adjustments and sometimes tearing down and rebuilding the machines or parts thereof. This is due to the fact that the transfer machine involves a rigid arrangement of power tools which are aligned with a work carrying conveyor. As the work passes along the conveyor it is grasped at each station and positioned respective to said machines by handling fixtures which are designed specifically for the particular work. At each machine, the work is operated upon by a movement of the cutting tool which is determined by mechanical camming, linkages, etc., inherent in the machine set-up. As such, the set-up is inflexible and the machine may be economically employed only where mass production of a single item or product is employed.

The difference between my system and the conventional automatic production or transfer machines is that I attain a high degree of flexibility by providing a series of work holding units either self propelled or moved on a conveyor each of which is supplied with predetermined means for selecting one or more of a variety of machines to perform an operation on work held therein, and each of which is supplied with a simple command system directing the path of travel of said unit and said machine operations in correct sequence. As such, my invention permits a variety of different products to be operated upon without changes in the set-up of the basic machines. My systems are ideal for the job shop receiving orders for the quantity production of various items, and for the manufacturer who has a continual flow of a number of items and is constantly introducing new items. By the use of standard memory recording devices, punched cards and tapes, magnetic tapes, printed circuits, sequencial switching, etc., I am able to change the command requirements for any particular operation or operations on a particular product in the simplest and quickest manners. In subsystems, I provide a command device with each work holding unit directing movement of the product and (or) the machine tool. Each machine therefore remains almost as flexible as if it were attended by an operator. In other systems hereinafter presented I provide simplified automatic handling of work in process incombination with station and position detection, and initiating devices and quickly presettable predetermining computers which permit highly flexible automation at low cost.

SPECIFICATION

It is a general object of this invention to greatly improve and lower the cost of automatic production and automation set-ups.

It is another prime object of this invention to provide new automatic production systems which are extremely versatile in that a variety of different products or work pieces may be handled, one after the other if necessary, and be operated on to completion without manual changes or alterations in the production machine or conveying set-up.

Still another prime object is to provide new and improved means of automatic production wherebye all work in process transportations, machine operations thereon, inspections, assemblies, etc. are done automatically and under the control of preset time-sequence computers.

It is a fourth prime object of this invention to provide new and improved means of automatic product handling and transporting wherebye the need of manual attendence or direction is eliminated.

A fifth object of this invention is to provide new and improved automatic devices for moving work in process to any point in a given volume and at the same time provide sufficient support to said devices for said work to be operated on by machinery.

A sixth object of this invention is to provide new and improved automatic means of moving work in process by a unit conveyorized carrier having means to move or direct movement of itself, the work, machine and tool to perform operations thereon at each of said machines.

A seventh object is to provide new and improved means of automatic production wherebye the product is always referenced while in process to a base known to a command system assocaite with a device conveying the product and (or) to production machines working on said product.

It is an eighth object of this invention to provide automatic production devices and components which are not only flexibly applicable to a variety of operations but are adaptable to standard conveying equipment and machinery.

It is a ninth object of this invention to provide new automatic production conveying systems and devices which are so flexible that most any product in a certain size and weight range may be operated upon by any machine accessible said conveying system.

A tenth object of this invention is to provide command operated automatic production systems with means permitting predetermined, yet easily adjustable , sequencial operations to be performed in said system within the realm of said command sequences.

An eleventh object is to provide new and rapid means for changing command recordings utilized in command computers for automatic production.

A twelth object is to provide new and improved automatic production devices driven by command computers which also control inspection devices having feedback provision, therebye greatly improving the precision of such devices.

A thirteenth object is to provide new and improved computers to be utilized in automatic production machines and systems.

A fourteenth object is to provide devices and systems for automatically and rapidly handling work in process, finished goods, or materials to and from a storage area with equipment which is low in cost, simple to operate, easy to maintain and adaptable to a variety of products and operations.

A fifteenth object is to provide improved means for automatically locating reference points in an automatic conveying system without the necessity of physical contact between the conveyor travelling unit and the conveyor trackway at said referencepoints.

A sixteenth object is to provide automatic production systems which may be used to perform the function of the conventional automatic production or transfer machine yet is more flexible and more easily altered and adjusted.

Fig. 1 is a plan view showing a part of a typical automatic production line of this invention and individual work carrying units situated at spaced intervals along said line.

Fig. 2 is a partially crosssectioned end view of a monorail travelling work carrying unit a number of which comprise the means of transporting work in process to preselected stations and machines such as those of Fig.1.

Fig. 3 is a partially crosssectioned side view of the monorail track and conveyor of Fig. 2. Fig.3', a modified section of Fig. 2.

Fig. 4 is a partially crosssectioned end view of a bi-rail conveyor unit which is a modification of the unit of Fig. 2 and 3 .

Fig. 5 is a partially crosssectioned end view of the conveyor unit of Figs. 2 and 3 showing and overhead monorail mounting showing means for station identification and locking said unit respective to said monorail when so identified.

Fig. 6 is a partially crosssectioned side view of Fig. 5.

Fig. 7 is a partial isometric view of part of the conveyor unit of Figs. 2 and 3 showing photoelectric means of identifying a station or position on said overhead trackway.

Fig. 8 is a partial isometric view of the lower section of an overhead driven unit conveyor work holding assembly at a work station or machine showing another means of identifying said machine by photoelectric means.

Fig. 9 is a partially crosssectioned end view of the conveyor unit of Fig. 4 showing modifications in the design of the conveyor and in the mounting of the overhead trackway.

Fig. 10 is an end view of still another modification of the conveyor ,trackway and mounting of the device of Figs. 1 and 2.

Fig. 11 shows by an end view, a modified conveyor unit work carrier at a work station showing lateral supporting means employable during operations on the work hold thereby.

isometric
Fig. 12 is an ~~isometric~~ and an end view of an aligning and supporting device shown in Fig. 11.

Fig. 13 is a partial endview of a work conveyor unit of the invention at a machine tool showing another means of engaging and supporting the unit during machining operation of the work held thereby.

Fig. 14 is a partially crossectioned, partial end view of an automatic machine tool bed or work platform and work conveyor unit platform showing means electrically coupling the two together.

Fig. 15 is a partially crossectioned partial end view of the units of Fig. 14 showing limit switch and solenoid operated switch control means between the two.

Fig. 16 is a partially crossectioned, partial end view of a monorail work conveyor unit at a machine tool showing modified work clamping means.

Fig. 17 is a partially crossectioned, partial end view of a machine tool base or platform with the conveyor units of this invention thereat show showing coolant flow and lubricating means associated with machining on work held thereby.

Fig. 18 is a partially crossectioned ,partial end view of a modified work carrier unit riding on a continuously moving belt type conveyor showing also station selection and station handling and clamping devices associated therewith.

Fig. 19 is an isometric view of a modification of Fig. 18.

Fig. 20 is a partially sectioned ,partial isometric view of command computer which may be applicable to control the motions of the aforedescribed devices.

Fig. 21 is a diagramatic view of the device of Fig. 20 in circuit with some of the aforedescribed components showing also inspection means which may be associated therewith.

By utilising the devices and systems hereinafter described I am able to provide systems of automatic manufacture of the following nature. All involve an array of machine tools, assembly machines, inspection and finishing devices, etc. which are positioned flanking a conveyor line for moving the work.

(1) A system whereby a self contained work holding fixture is self propelled and (a) moves the work to a series of stations or machines preselected thereby, (b) automatically prepositions or zeros the work respective to each machine, (c) commands starting of the machine or machine tool, (d) automatically moves the work respective to the tool during the operations by command, (e) automatically removes the work when the tool has finished its operation thereon and (f) moves it on to the next predetermined station.

(2) A system whereby a self contained work holding fixture is self propelled and (a) moves the work to a series of stations or machines, (b) automatically prepositions or zeros the work or work fixture respective to each machine, (c) commands clamping or holding of the work and (or) work holding fixture at said machine, (d) commands starting of the machine or machine tool, (e) commands movement of the machine or machine tool respective to the work, (f) commands stopping of the machine, (g) commands unclamping or holding of the work and (or) work fixture when said commanded operations are completed, (h) automatically removes the work from the machine and (i) moves it on to the next preselected station.

(3) A system whereby a self contained work holding unit or fixture is self propelled and (a) moves the work to a series of stations or machines preselected thereby, (b) is automatically stopped and zeroed at each preselected machine, (c) is automatically supported for machining or commands support upon stopping, (d) commands movement of the machine or machine tool respective to the work and operation of said tool thereon, (e) commands stopping and withdrawal of said machine tool therefrom and (f) moves the work on to the next preselected station.

(4) A system whereby a self contained work holding unit or fixture is moved on a powered conveyor line and is provided with means for (a) preselecting a series of machines along said line and (b) commanding or otherwise initiating means for moving said work holding unit off said conveyor to each of said machines and prepositioning it respective thereto, (b) means clamping or otherwise holding

it at said prepositioned position, (d) said work holding unit next commanding the movement of said tool respective to the work thereon, (d) commanding the stopping of said tool when said machining or operation is completed and (e) initiating the action returning the work holding unit to the conveyor.

(5) Systems whereby the actions described above are supplemented by automatic actions at the machines performed on the work which are initiated by movement of the work respective thereto but are easily adjustable at the machine to meet a variety of product requirements by the use of replacable command recordings directing command systems inherent in the machines.

(6). Systems whereby some of the actions described above are supplemented by the provision of one or more limit switches actuated by the movement of the work motors directing motion of the work and or said machines.

(7) ~~Systems for automatically storing and removing products from storage without man attention.~~ 13 14

It will be seen from the following descriptions and the accompanying drawings how I attain a high and most flexible degree of automation with a minimum number of positioning, clamping, work grabbing and work moving fixtures. This is accomplished by providing fixtures, and clamping devices which are flexible, capable of referring work clamped or held therein to base lines common to the machine tools and automatically adjustable to different work pieces or assemblies.

In order to simplify the discussion to follow, the following symbols will be utilized to abbreviate or define motions and components common to the devices and systems:

The letter "X" will refer to motions in the X direction, which is parallel to a line extending from machine station to station. As a subscript, X denotes a device such as a motor (M) associated with motion in the X direction.

The letter "Y" will refer to motions in a horizontal plane which are perpendicular to the direction of X or motions towards and away from (-Y) the machines at each station.

The letter "Z" will refer to motions vertically. Z and-Y used as subscripts denote devices/or associated with verticle movements of the conveyor unit or movable machine.

The letter R refers to rotary motion of the tool, conveyor unit or work. M refers to motors driving said conveying units, work or tool or computor, W refers to work pieces or assemblies operated on. T refers to station machine, or machine tool. I refers to station machines which are an inspection devices, A refers to a station machine which is an assembly device.

In the conventional automatic production machine, commonly called the transfer machine, an article of manufacture such as an engine cylinder block is clamped in a chuck or holding fixture, prepositioned therein and placed on a conveyor which moves adjacent a series of machine tools. At each machine or station, said article of manufacture is operated upon by the tools of said machine. After it is then handled by special devices associated with the particular machine which grasp it, pick it up off the conveyor, and move it to a position where it is operated upon by the specific machine tool. It can easily be seen how inflexible this set-up is. Any changes in the preset operations on the work or the sequence of said operations require expensive and time consuming changes in the kinematics of operation of each machine, if this is at all possible without completely altering the design of the transfer machine.

JHL

Whereas the aforedescribed automatic production machine involves handling the work at each station by devices peculiar or adapted to that station, and the product, in my invention I attain a far greater degree of flexibility by rigidly fixing an array of machines, designed to perform particular operations (drill presses, borers, millers, grinding machines, lathers, honing machines, presses, welding machines, inspection devices, spraying machines, assembling machines, etc) on a variety of products, respective to a conveyor system which is so designed that all motion of said work respective to said machines is accomplished by a unit work carrier riding on said conveyor. I also provide automatic means for moving the tool respective to the work or the work to the tool, to enhance the flexibility and improve the precision of my system, but said actions are not necessarily peculiar to each station and may be quickly adjusted for any specific product. I have thus eliminated the necessity for having a work holding or moving device at many of the machines and utilize such apparatus or devices only where it is easier to so do or to improve the operation when so necessary. When

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this is done, I provide work holding means at the machine which is (a) automatic, (b) can be commanded by the work holding fixtures command system or is easily and rapidly adjusted or changed at the machine station.

In one of my conceived systems, the work is clamped in a conveying device and power means associated with said conveying device, is provided for automatically moving said work to any point in the vicinity thereof. This is accomplished by a command system which starts and stops electric motors in sequence to direct said conveying device to any position in the conveying area, such as to a predetermined machine. The action is followed by the further movement of the work automatically to said machine. Machining may be accomplished under command by (a) movement of the conveying unit and the work held therein respective to a machine cutting tool, (b) by prepositioning the work at the machine and directing or causing said tool to move respective thereto and (or) moving it further by the machine elements respective to the tool. The command system has a means peculiar to each product for predetermining the X, Y, and Z, coordinate motions of the work to preposition it respective to each machine and command any necessary motions of said unit during machining operations. The entire automatic operation on a product may thus encompass the complete production of said product from the raw material or, complete finishing operations on a partially completed product, which may include inspection operations and feedback commands for completion of the operation, and to correct the tool. What is essentially needed for products to be applicable to these systems is, means designed or inherent in each product for determining reference or base lines when it is clamped or held in a work holding fixture on the conveying unit, so that the command system may correctly direct proper motion of the various machine tools respective thereto.

The entire operation or sequence of operations on a variety of products may be predetermined as a function of the relative motion of the work holding devices. Servo motors driving the work conveying device may be controlled by pre-recording means and operated per se, or in conjunction with mechanical switches, electrical contact means or photoelectric cells actuated by movement of the work or work conveying unit. Said pre-recorded command mechanism may employ any one of a number of mechanical, electrical or magnetic memory devices such as (a) a punched tape, (b) punched card, (c) magnetic tape, etc. which is coupled to a control unit which converts said recording to an electrical signal and mechanical motions. Machine tools per se have been run automatically by these and other preset or pre-recorded means which direct or command motion of servo motors or solenoids driving the tool

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at a predetermined rate in the X, Y and Z planes and in predetermined sequence thereof.

Fig. 1 is a plan view of part of a possible production line layout in the realm of this invention. The line may extend beyond the space limits shown. It comprises, in part, a track 21 or vehicle guideway, with a series of self propelled vehicles or work holding carriers 22 riding on said track. Said trackway preferably doubles back on itself or forms closed circuit so that the individual work holding carriers 22 may arrive at the starting point of the cycle without backtracking. Adjacent to or flanking said trackway are an array of machine tools T, inspection devices K, assembly machines A, finishing machines F, etc. In fact, any tool, mechanism or handling device capable of performing operations on work of a specified realm of manufacture may be provided along the line.

The basic component of this invention is a self propelled work carrying vehicle travelling on said trackway which is provided with mechanical and electrical mechanisms for moving the work respective to the tools. In my preferred embodyment I provide an overhead conveyor rail system on which said vehicle 22 rides. Extending downward from said vehicle is a verticle support or column 23 (shown in Fig. 2 and 3) which travels therewith along said track 21. The work may be held in a jig rigidly affixed to the column 23 and moved from station to station where the various machines operate on it. For a more flexible arrangement, I provide means whereby the work holding jig or platform 36 is movable respective to said column number 23, so that said work may be moved to and from each of said machines if necessary. Of the overhead conveying systems applicable to this invention, a monorail or bi-rail layout are conceived, each of which involves a different modification of the vehicle column assembly and driving means.

Monorail System:

Figs. 2 and 3 show an overhead mono-railing or track 21 (illustrated as an I-beam though having any desired shape) which extends along and over a row or line of machine tools, inspection devices, automatic assembly mechanisms, finishing devices, etc.) as illustrated in Fig. 1. A carriage or vehicular dolly 22 is adapted to travel longitudinally thereon from station to station. Fig. 3' is a partially sectioned view of the track 21 and carriage 22 mount having wheels 24' engaging the I-beam web for lateral stability and a solenoid 65' mounted on 22 adapted to frictionally engage against 21 to lock the carriage 21 on the overhead track when so needed for machine operation. The suspended carriage 22,

mounting four or more wheels 24, is adapted to run along said trackway with said wheels rolling on the flanges of the I-beams or trackway extending therefrom. Electric motor Mx (Mx also is used to designate the motor speed control and braking mechanism associated therewith) is secured to said carriage 22 on a mount 26 and drives it by rotating wheels or an odd wheel 25 which frictionally engages the bottom of the I-beam or track flange. Mx is supplied with electrical energy from two conducting wires or rails 28 which are mounted to extend parallel to each other and to the trackway 21. Contact therewith with brushes 27 extending from the carriage 22 which either sweep or roll on said wires 28 provided electrical connection between a power supply and the servo motors associated with the conveyor assembly.

The verticle column 23 extends from the carriage 22 and may be rigidly affixed thereto, rotationally mounted as in Fig. 2 or arranged to telescope on itself to provide verticle motion or rotational motion of the work clamping or holding assembly mounted below. By rotating the column 23, greater flexibility is added to the device as the work hold below may be rotated respective to the station machines. This may also be of advantage in automatic loading and removal of the work from the conveyor unit. Rotation is accomplished by the use of motor Mr which is mounted on the side of carriage 22 to rotate the columnar member 23 thru gears 33 and 34. The latter gear ,34, is shown extending perif>erally about the upper end of said column and is rigidly to the top thereof at the flange 30. A vertically extending bearing pin or axle 31 having flanged ends 32 rotationally supports the column assembly below carriage 22. Tapered roller or ball bearings 49 are mounted therebetween and reduce rotational friction. The work W is secured in a work holder which comprises a platform 35 extending laterally from columnar member 23 and mounted to be movable in and out thereon or providing movement of the work-clamps or jig 36 laterally respective to 23. The numeral 36' refers to a solenoid or servo motor coupled to move the vise or clamps 36. The platform 35 is movable laterally on a cylindrical column 35' and may be locked in any position thereon. The column 35' is also movably mounted respective to 23 by being slidably mounted in a bearing member 38' extending from collar 38 which in turn is slidably mounted on column 23. Motor My, mounted off 38 drives 35' thru spur gear 39 and spur 39', the latter being mounted rigid respective to 35' on bearing lugs 40 which are mounted off the column 38 to clear collar sections 37 and 38'. Various other means of driving the platform 35 are feasible. An arrangement permitting access of W to both sides of 23 would eliminate the need for rotating the column 23. Also, if the tools of the machines MT, A, I, F, GHE

GHE

which are employed. are provided with automatic means for moving respective to the station may be commanded to ascribe the necessary motions respective to the work, it would not be necessary to move the work held by the column and it (the work) could be rigidly mounted thereon. In such an arrangement, the system would comprise an array of self-powered carrier-column assemblies moving one behind the other on the conveyor line and stopping in front of selected machines.

It has been shown how the device of Figs. 2 and 3 moves the work laterally to the conveyor track. Movement up and down on the column is attained by provision of servo motor M_Z the shaft of which is coupled to a screw or worm 42 mated with a threaded collar 43 which is secured to a cross-bar 44 affixed at its ends to the collar 38. The bar 44 is guided in verticle travel in the slots 45 in the column 23 and moves up and down with the turning of screw 42 by motor M_Z. 41 refers to a base or cap of column 23 on which M_Z is mounted. The numeral 41' refers to a bracket secured to the wall of column 23 which supports the end of screw 42 in bearing. It is noted that various other mechanical or hydraulic arrangements may be utilized to move the collar 37 up and down on column 23 such as worm and spur gear drives, chain drives, etc.

The motors M_X, M_Y, M_Z and M_R are powered by electrical energy supplied thru brushes 27 riding over the electrical conducting rails 28. While M_X and M_R are directly accessible to the brushes 27, M_Y moves up and down on base or collar 37 and M_Z is situated within the column 23. If M_R is utilized in the design, making the column turnable respective to the carriage 22, the conducting elements or wires 51 extending from the brushes 27, are most conveniently connected to the motors below by passing thru its center of rotation. They are shown passing thru the center of pin 31 and extending to the motors M_R and M_Y. The numeral 47 refers to a computer used to direct automatic rotation of the motors aforedescribed and will be discussed later. In order to allow for the verticle travel of the assembly of 38 and the components mounted thereon, motor M_Y is electrically connected to the electrical system of the column 23 via wire 46 which has sufficient free play to account for travel.

Lead wire 46 is flexible and long enough to permit 38 to ride up and down
on 23 from its highest position thereon to its lowest. By operating the motor
controls Mx,My,Mz,etc. in the proper sequence the work W may be driven to
any particular station along the conveyor line or trackway,moved towards the
machine,prepositioned in the Z direction,moved respective to the tool during
its operation thereon,removed and returned to its aisle position and moved on
to the next station. The entire action may be predetermined by a presetting
or recording command device 47 or may comprise a combinations of commanded
actions supplemented by automatic actions initiated or controlled by limit
switches or photoelectric devices common to the system and actuated by movement
of the carriage-column assembly or work holding platform35.

Fig. 4 is an end view of a work conveyor unit utilizing a birail trackway
running overhead and past an array of production machines. This arrangement
may utilize the column 23 and carriage 22 of Figs. 2 and 3 which rides later-
ally(to and from each machine) on the crane crossbridge 52 which may also be an
I-beam. Wheels 24' supported at the ends of 52 ride on a track 54 mounted on
the upper surface of the trackway I-beams 53. Motor Mx drives the bridge along
the track 54 thru gears G and G'. The verticle columnar member 23 of Figs. 2
and 3 is shown modified in Fig. 4 to illustrate another possible design. In Fig. 4
the column consists of two sections, an upper tubular section 23' secured to
the bottom of carriage 22' and a lower columnar section ,circular in crossect-
ion and slidably mounted to telescope into the bottom of 23'. Secured to this
lower section 23" near its lower end is a laterally extending shelf or platform
38 on which a work holding bed or mount 58 is mounted. The motor Mz ,mounted on
23' is coupled to drive 23" up and down therein via spur gear 39 and spur 39'
which is secured therein to the upper end of 23". Rotation of the column assem-
bly may be accomplished as in Figs. 2 and 3 but is not shown in detail in
Fig. 4 which is used only to illustrate the cross-bridge doll-column arrangement.
The notations Mx,My,Mz,etc. refer not only to these servo motors but also to
their controls including braking mechanisms for stopping them on command
specified time duration after receipt of the signal to stop.

A preferable system for determining the type,degree and sequence of motions
required to perform specified operations on a product moving in the system is
one wherein the various work stations or machines are identifiable by a device
at the work carrier which initiates or commands actions upon identification.

Fig. 3' is a crossectional view of the upper section of Fig. 2 showing means
further holding the column-carrier assembly at the station by use of a solenoid
65' mounted on 22 the ram 66' of which automatically engages the flange of 21.

mechanical means
Figs. 5 and 6 show mechanical means whereby the travelling column and dolly
assembly may identify the work stations in the X or conveyor travelling direction.
Once said station is so identified the dolly may be made to automatically stop
permitting the machine at the station to perform its operation automatically
thereon at its stopped position or/do so following movement of the work to the
machine to attain predetermined position at the machine.

Identification of the station may be accomplished in one of several manners.
Fig. 5 is a partially cross-sectional end view of the conveyor and dolly and Fig. 6
is a partial side view thereof. Identification is made by the use of a limit
switch or switches 59 mounted on the dolly base 22, the arm 60 of which is depressed or thrown as the dolly passes pins or projecting elements 61 extending
from the flange of rail 21. Said switch 59 is in series with the motor MX
driving the dolly or may be coupled to sequence command computer 47 in a circuit
which will initiate a series of actions stopping the dolly, positioning the work
and starting and stopping other motors operating the conveyor or station machine
mechanisms. The arrangement of Figs. 5 and 6 shows two pins 63 and 62 spaced
laterally apart and a distance apart from each other in the X direction on the
rail flange 21'. The throwing of the first switch by 62 will turn off or slow
down the motor MX. The throwing of switch 60' by 63 may be coupled to a brake
stopping MX and the dolly at a precise X position. One switch would suffice if
it, in addition to shutting down motor MX it were coupled to a solenoid 65 actuating a pin or projection 66 to extend against the conveyor railing and become
engaged in hole 67 therein, thereby stopping and (or) locking the dolly respective
to the conveyor at the desired station. Here again the solenoid and switch preferably are coupled together thru the station selecting component of the command
computer making it possible for the dolly assembly to select certain stations
while bypassing others if necessary.

To Slow Down & Stop

Another means of work station identification and selection is shown in Figs.
7 and 8 which illustrate photoelectric cell 68 and light source 69 combined and
mounted on the side of 22 to scan, for example, the upper flange of beam 21.

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A small reflector 70 placed on the flange 21' of the I-Beam will reflect the beam from the light source back into the phototube and may thus be used to identify the machine station. Said photocell is in a circuit with a photoelectric control 68' which causes a relay to close a switch when light is reflected from 70. The closing of said relay actuated switch may be used to initiate an action braking the assembly and signal the device commanding motion of the work holding platform 35 to move it towards the work. If the command computer 47 is utilized, the closing of said solenoid actuated switch may be utilized to signal the computer which by use of a mechanism such as a multiple circuit predetermining counter may be used to determine whether or not the machine at the station is to operate on the work.

Fig. 8 is merely a variation of Fig. 7 whereby the photocell 68 is secured to the column 23 and is ~~[illegible]~~ energized by light reflecting off reflector 70' positioned near the base of the machine tool MT.

Fig. 9 is an end view of a production line arrangement in the realm of this invention wherein the bi-rail work conveyor assembly of Fig. 4 is utilized. Station machines 71 and 72 situated on either side of the conveyor line are utilized to support dual I beams 53' and 54' and thereby eliminate the necessity of providing mounts or ceiling brackets for said trackway. If modified standard-power tools are utilized, the machine frames, which are designed to resist machining forces, may be sufficiently strong enough to support the overhead rails and the forces of machining. If not, re-enforcement of their verticle members may be necessary. The I-beams or tracks 53' and 54' are shown modified with a V or wedge shaped identation 74 extending from the upper surface downward therein. This is used to center and provide lateral support to the wheels 24' riding thereover and is accomplished by providing a wedge shaped circumferal projection 24" at the center of the outer circumference of each wheel. Said construction reduces the amount of side play in the assembly ~~during machining~~ and serves as a guide for the wheels as they travel along the tracks. The numeral 71' refers to the bed of either machine on which the platform rests prior to machining. Also shown in Fig. 9 is another means for holding and supporting the work at the machine while being worked on. This is accomplished by use of an electro-magnet 73 in the machine bed 71' which is energized by a switch SW actuated by 47 under command or by movement of the converyor platform 35, workjig 36 or work W and engages 35, 36 or W depending on how the work is held and conveyed about the system. Also

163 shown in Fig. 9 are the electrically elect[...]r conducting rails or wires 28, which are
hold by brackets 79 insulatedly mounted off the frames of the machine tools
71 and 72, or mounted off the I-beams.

Fig. 10 shows a mono-rail trackway 21' supporting and guiding a modified
conveyor assembly from machine to machine. Said track 21' is supported by the
frame of the machine and is mounted thereon at the upper front section thereof
as shown. The numeral 21" refersto a support extending from the top of the
machine frame to the track 21'. The modified conveyor carriage comprises an
open channel shaped dolly rotationally mounting wheels 24' and 24" which
are vertically supported in bearing by the walls of said carriage and which
ride against the inside and outer face of the outer flange of the I-beam 21'.
The motor M is coupled to the shaft of 24" which rides on the outer face of
the I-beam flange and drives said wheel to move the assembly along the trackway.
While the end view of Fig. 10 only shows two wheels, four or more are prefer-
ably utilized to stabilize the mounting. Said wheels are mounted behind 24' and
24". Wheel 24" is shown wedge shaped at its rim in crossection and said
rim rides in a wedge shaped groove in the flange of the trackway 21'. This
construction is utilized for purposes of alignment of the assembly of 22'
and 23 respective to the track 21' and hense the machine or machine tool.
It is noted that the overhead track 21' of Fig. 10 need not be supported by
the machine frames as illustrated but may be mounted hanging from the ceiling
or from poles or supports extending from the floor.

The work holding jig 36 shown in Fig. 10 is modified to hold several small-
er work pieces W' each of which is to be operated on by the machine tool at the
station. It is illustrated merely to show that system is so versatile that it
is adaptable to take not only heavy work such as automobile engine cylinder
blocks which are run thru the conventional transfer machine but also a variety
of smaller item one at a time or in groups mounted on a single work conveyor
unit. The basic requirement for the particular product handling and operational
problems is the provision of the proper work holding jig or clamps 36, means
referencing work held therein to the conveyor assembly and(or) the machine
tool base. The letter S refers to an adjustable stop (adjustable in and out) at the machine or the
the back face of the machine bed MTB (referred hereafter as 71') against
which the platform 35 or work jig 36. The letters SW refer to a limit switch(s)
mounted on S and (or) 36 which may be utilized to stop the work at the machine
and start the machine in operation when 36 is propositioned. SW_A is a limit switch
on 71' which may be used to stop the longitudinal travel of 35.

various means
Figs. 11 to 15 show ~~various~~ means of securing the work conveyor lateral
the machine
platform 35 or column 23 at the machine and electrical coupling means and
control switching devices between the machine and conveyor. It is not necessar-
ily intended in the drawings to present a particular system of automatic man-
ufacture or, in this application to discuss at length the elements of servo-
mechanism systems necessary to perform precision machining operations using the
mechanical handling components heretofore described or, to discuss in detail
electromechanical and electronic computing devices for commanding precision
operations by precisely controlling the movements of Mx, My, Mz, etc. Suffice it
to say that the letters Mx, My, Mz, Mr, etc. refer not only to electric motors
generating a particular motion but also to precision controls of the motors
guaranteeing a constant speed, predetermined rate of change of speed, predeter-
mined type of reversing and braking. Where a machine tool MT' is shown, for the
particular embodyments or combinations of Figs. 11 to 15, it is assumed that
the tool MT8 is preadjusted or commanded to perform in a given manner respective
to the work and that said action is initiated by motion of the work or work con-
veyor relative to the machine, or is initiated and controlled by the command
located either at the conveyor assembly or at the machine MT
computer 47, which may be a simple electro-mechanical device opening and clos-
for
ing switches starting and stopping said motors after predetermined time inter-
vals or may be more complex analog or digital computing devices commanding said
actions and working off magnetic, electrical or mechanical memory systems.

Switch means has been shown in Fig. 5 for stopping the vertical column 23
opposite the desired station. The action opening switch 39 which stops the Mx
motor and brakes the conveyor motion may at the same time be utilized to close
a circuit starting up My to drive platform 35 to the machine bed 71. This may be
accomplished by providing switch 59 as a double acting switch which closes a
circuit with My when it is depressed and Mx circuit is open or by providing a
second switch adjacent to 59 which is compression closable and closed by project-
ion 61 at the same time 59 is opened thereby. A limit switch 89, situated on the
end of platform 35 and actuated when the platform makes contact with the machine
backstop 8 or base upper surface 71' may be used to stop motion of 35 by opening
a circuit with My, and also may be utilized to initiate other actions such as
further securing of the platform 35 at the machine, clamping or unclamping of
the work held thereon, release of the work, initiation of actions picking up
the work, etc. Another switch or switches situated at the machine may be used

to initiate still other desired actions such as ; further means securing the platform 35, the work, or the work holding jig 36 or section thereof at the machine by holding devices associated with the machine; means moving the work off the platform 35 to the machine bed 71; movement of the machine bed MTB or the machine tool MT' respective to and on the work after a delay permitting required operations such as clamping or holding the work, zeroing or prepositioning the work, etc.; Still another switch associated with the machine may be actuated upon completion of machine operations on the work at the station by, for example, withdrawal of the machine tool (as in Fig. 15, switch 60' contacted by projection 60" extending from the tool head MT') may be utilized to signal the conveyor to with-draw the platform 35 from the machine by actuating a solenoid ram 93' to close a switch 88 on the platform 35 which in turn closes a circuit with a solenoid switch in the My control which remains closed, reversing My to drive 35 away from the machine MT until stopped when the platform has been fully withdrawn. If the birail system is utilized, the mechanism stopping My may be similar to the mechanism of Figs. 5 and 6 stopping Mx. A projection 63 as in Fig. 9 closes a switch similar to 59 mounted projecting from 22' opening a circuit with Mx which mechanisms stopping or braking Mx. The projection 63 may also be utilized to depress a switch mounted on 22' closing a circuit with Mx and a power supply and starting the motion of the assembly to the next station or machine. 15

Thus it is seen that a command system based entirely on limit switches end stops along the trackway, on the column 23 or work platform 35, at the machine tool MT bed 71' or at other points on the machine coupled with solenoid or other actuated means signalling the completion of ending of operations by the machine to the conveyor may be utilized in one system of automation. In such a system it is required that the machines be adjusted or commanded to perform in a predetermined manner on the work. While this arrangement is not applicable to more than one product at a time on the line, nevertheless the system could be made very flexible by the provision of a quickly changeable and easily alterable command system such as that of Figs. 20 and 21. The system also requires the use of circuits involving the use of hold down switches which may be closed or opened by a pulse of current initiated by the actuation of one of the limit switches aforedescribed and to be described which are used to indicate motions and positions of the various movable parts of the system.

Fig. 11 is a partial end view of a production line work station showing an overhead conveyor driven verticle support column 23 of the invention with means provided to support said column at the station against bending moments thereon and hence against deflections thereof when for example lateral leads are imposed by a horizontal cutting tool such as the drill 75. Means for steadying and positioning the column 23 and hence the work W against axial loading comprises a verticle support or frame 76 positioned on a base 77 and mounted on the floor at the station to resist the forces of the cutting tool thereagainst. When the column 23 is opposite the machine tool 75, it stops and is automatically backed or supported by 76. The tool then performs on the work and leads are transmitted thru W, 35 and 23 to verticle 76, therebye improving operations while the work is held by the conveyor unit.

Several means of automatically engaging the verticle column 23 during the machining operation at the work station are shown in fig. 11. One method comprises utilizing a shaped bucking bar 78 secured to 76 and positioned to engage a mated bar 79 mounted on the column 23. Fig.12 shows an end view and a partial isometric view of the bucking bar 78 having a wedged shaped logitidudinal indentation 78' therein adapted to engage and mate with a longitudinal wedge shaped projection 79' extending from 79. Either or both 79' and 78 are tapered to permit ease of engagement between the two as the column 23 aproaches 76. The numeral 80 refers to an electro-magnet positioned on 76 to draw 79 against 78, and therebye add additional support to 23 during machining operations. The numeral 80' refers to a second electro-magnet facing and adapted to engage 23 which may be used per se or in conjunction with 79 and 80. A switch SW' projecting from 76 to engage 23 with its motion to the station may be utilized to engerize 80 and (or) 80'. Disengagement of the electro-magnets and 23 may be attained by a solenoid energized by the afore described command computer 47 or motion of the tool 75 as it finishes its operation on the work and withdraws therefrom therebye actuating a limit switch (see Fig 15). The numeral 75' refers to the base of the machine or machine tool 75. SW refers to a limit switch projecting from 75' which is utilized to initiate action of 75' on the work W.

Fig. 13 is a partial end view of a work conveyor unit at a station machine MT showing another means for engaging the verticle column and supporting it during machining operations. Although not shown, all actions are initiated by either limit switches projecting to be closed by motion of the column 23 or by

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or by the use of photo electric devices at the station. In Fig. 13 I show 2 means of physically engaging the column 23 which may also be used to engage the latteral platform 35. One means comprises the utilization of a solenoid actuated ram or pin 81' adapted to be moved by said aforedescribed station mounted limit switch or photo cell actuated switch against said column 23 or engaging a hole 87 therein. This serves the dual function of both prepositioning the column at the station in supporting it against lateral machinging loads. The numeral 81' refers to the solenoid actuating pin 81' which is shown mounted on a projection from the base 71 of MT, and projecting upward therefrom to engage the bottom of 23. I also show in Fig. 13 a solenoid 81'' projecting latterally from 71 which may be used in conjunction with the afore described solenoid or by itself. Two of said laterally projecting solenoids may be used to wedge the column 23 therebetween and thereby position and steady it. Still another means of engaging 23 at the station is to use electrically actuated clamps which are not shown and which altho more costly than the solenoids per se may be necessary for certain types of machining operations.

Also illustrated in Fig.13 is a more versatile machine which may be used to add flexibility to the operation in the event that x,y,z, and rotational motions of the tool respective to the work are necessitated. While it is not intended to go into the finer details of the mechanism of the machine of Fig.13, the major components of said machine are described in order to understand their function and their relation to the automatic production systems of this invention. The machine tool frame MT and upper section MT' ~~which~~ is rotatable thereon by motor MT_R. The machine tool head 82 is mounted on a column or track 82' and is drivable thereon towards 23 by the motor MTy mounted on MT'. The motor MTy drives the cutting tool of 82 up and down and a motor mounted in 82 may be utilized to rotate said cutting tool. The motor MTx mounted on MT' may be used to drive the assembly of MT', 82' and 82 parallel to the conveyor trackway. The machine of Fig. 13 may be utilized in automatic production systems having features aforedescribed and particularly to be described in Figs. 14 to 17. Fig. 18 is a partially crossectioned partial side view of the end of work holding platform 35 and part of the work table 71 under the tool head MT. The platform 35 is driven towards the tool bed 71' until it comes to rest against the wall or backing S. The numeral 83 refers to wires mounted within bed 35 and extending from a sequence command device to be described. Said device may be mounted

may be mounted within the platform 35 or colum 23 and ,as heretofore described, may be utilized to command selection of station machines and (or) their particular performance on the work W. (See Figs. 20 and 21). The device,previously designated by the numeral 47, may command ,in addition to station selection, such actions as engagement and disengagement of the work conveyor column 23, at the station,the platform 35 at the machine bed 71', prepositioning of the work W respective to the machine, removal of the work W from its conveyor holding jig 36 and its prepositioning and clamping at the machine toolbed, motions of the machine tool respective to the work and,unclamping and removal of the work from the machine. To accomplish these functions the computor 47 may, as stated, be mounted on or in the work carrying conveyor, and array may be mounted one at each machine to be started by the approach of the work holding conveyor, or the actions of the machine may be commanded from the conveyor mounted computer 47.

In order to convey electrical signals from the work holding conveyor such as those originated at the computer 47, to the various station machines and visa versa, I provide simple electrical coupling meansbetween the conveyor latteral platform 35 and the machine tool bed 71'. Wires 83 extending, for example, from the computer 47 are connected to surface mounted contacts 85 and 86 which are mounted on the end of 35 and are positioned to make contact with similar contacts 86 and 87 mounted on the machine tool base 71' or the end of the base S and electrically connected via wires 87' to electrical devices associated with said machine. ¶ In Fig. 14 two types of contacts are shown, both permitting flush mating of 35 with 71'. All contacting elements are insulatedly mounted on their respective bases in a housing 84' which is made of a nonconducting material. The upper contact 86 is a female conducting receptacle adapted to mate with the male fitting 87 thereopposite mounted on 71'. The lower contact 85 is mounted on a spring 85' and normally projects beyond the surface of 35. It makes electrical contact with jack 86 projecting from 71' which pushes 85 into the housing 84' permitting flush coupling of 35 with 71'. The command signal from 47 may comprise one of several electrical variables which direct a mechanical or electrical device or which commands a computer directing the tool to ascribe a predetermined action. conceived signal variables are (a) A constant voltage signal to a servo motor, the time duration of which determines the amount of rotation of said motor which determines a particular motion of the machine tool or devices associated therewith. (b) a variable voltage, the variations of which move a potentionmeter to control directly or indirectly a mechanical action thru an electrical servo, (c) pulses of current ,each or a group of which command

computers

1.B actions of a motor, solenoid, or other mounted at the machine MT, or other electrical devices. For example, pulses from computer 47 may be used to set a computer at the machine for the purpose of commanding inspection devices which function with feedback information being recycled to said computer to maintain quality control and keep the product within quality limits regardless of the wear of the tool. Or, the computer 47 may be electrically connected with inspection devices mounted on the work carrier such as x, y, z, electrical probes contacting the work to determine whether or not tolerances have been met by the machine. Two sets of mated contacts are shown in Fig. 14. In actual practice, where the are a number of circuits involved, an array of said mated contacts would be provided to account for a variety of circuit connections between the conveyor unit and the machine. Fi

Fig. 15 is a partially crossectioned view of the end of the platform 35 and the station machine bed 71 showing the aforementioned limit switch SW' designated as 89, and a switch 88 projecting from the bottom of 35. The switch 89 projects from the end of 35 and is utilized to signal the arrival of 35 at the end of 71 by, for example, turning off motor My. Shutting down My may signal the lowering of platform 35 until it is flush with the top 71' of bed 71. This is accomplished by providing the switch 89 as a two way limit switch, the projecting position illustrated permitting the closing of the circuit of My and a power supply and the inner position attained by the end of 35 butting against S opening said My-power circuit and closing a circuit with the control of Mz driving it downward. The switch 88, also a two way switch, when in the position illustrated (35) (projecting outward) permits anclosed circuit with Mz and a power supply. When it, 88) buts against the top 71' of base 71, it opens said Mz-power circuit stopping Mz therebye bringing 35 to rest. The motion of the machine tool may be initiated by a limit switch SW mounted thereon to be closed by motion of 35 butting thereagainst or by signals from 47 thru the coupling of Fig. 14. When the operations at the station have been completed, 47 may signal the removal of 35 from the machine bed 71 or said action may be signalled as follows: I provide one or more solenoids 93 mounted in 71 in a manner promitting its ram 93' to be projectable above the surface thereof when said solenoid is actuated. When the machining operations have been completed and the tool head is being withdrawn a limit switch 60' mounted near said head may be actuated by the movement of said head MT'. Closing of 60' may be utilized to cause the solenoid ram 93' to project above the surface of 71'. If 93 is positioned opposite 88, it may be

it may be used to further urge movement ment of 88 to a third position which againt
closes the circuit with Mz and a power supply. This will cause Mz to lift the
platform 35 and although the switch 93 goes thru a neutral or open circuit posit-
ion, the switch SW may be adjusted to open again retracting 93' and permitting
88 to quickly assume its first position which again closes the circuit with
Mz and the power supply. The utilization of the combination of the command
computer 47 directing actions which are initiated ,stopped,altered or suppli-
mented by a system of limit switches permits the attainment of a very flexible
degree of manufacture in that each work conveying unit may carry command in-
structions peculiar to the particular product it is conveying . Two different pro-
ducts ,for example may follow one another on a singel production line, the comm-
and system of each selecting the proper machines and commanding them to perform
accordingly on the work held thereby.

The initial cost of an automatic production system having individual work
conveying units each with its own command computer is high and is economically
desireable only where large runs of a variety of products are made. In Fig. 16
I show components of a system of automatic production which,although not as flex-
ible as some of the aforedescribed arrangements, would suffice for certain types
of production such as large runs by a concern manufacturing but a few products.
The system is flexible in that each production machine flanking the conveyor
trackway 21 is capable of being command operated by its own computer 47' which
is easily changed or altered . The machine tools of each of said machines MT are
capable of being moved in a desired volume by servo motors MTx,MTy,MTz ,MTr.etc.
The work W is held in a clamping jig 36' which is mounted on a platform 35'
which is rigidly secured to column 23. The letter MTBc refers to a clamping or hold-
ing servo or work conveyor situated at the base 71 of the machine MT which is
actuated to clamp orhold or move the work W or the platform 35' by the motion of
35' or W past a limit switch associated with MT. When the work W and (or) plat-
form are held at the machine,the tool under command of its computer 47' is driven
by its motors in sequencial x,y,z, and rotational motions to operate on the work
W. The numeral 73 refers to electromagnetic means for holding the platform 35'
at the machine bed 71 and 73' to electromagnetic means for holding the work W
against 35' if so needed. The means stopping and starting the work conveyor opp-
osited the machine MT is similar to that of the device of Fig. 15 whereby a sol-
enoid mounted in and projecting from the base 71 opens a limit switch 95 projecting from
23 stopping Mx and when the machining is completed ,93 is actuated by 47' to
again close 95 starting up Mx again. to drive the conveyor 23 to the next machine.

Fig. 17 is a partially crossectioned partial side view of the aforedescribed conveyor platform 35 at the machine tool bed 71' showing a design permitting the circulation of cutting collant and lubricants originating at the machine tool to flow over the work and back tot he machine for recirculation.. Anot or function in successful automatic machine tool operation is the removal of chips, grindings or other product wastes and I provide for this required function by removing said wastes from the machine with the removal of the work holding conveyor unit. At some convenient point along the conveyor line said wastes may be blown, washed, dumped or otherwise removed from the unit. Housekeeping at each machine is thus minimized and requires but a minimum amount of human attendance. It is concieved that machining wastes could be removed without difficulty by a separated belt or tubular type of conveyor but this would add considerably to the cost of installation.

In Fig. 17 I provide ducting in the form of thru and thru drilled holes 97 thru 35 and 35' which will align with directing 98 in the machine tool bed 71' during the machining operation. The base of 35 is sloped towards these holes so that oil flowing over the work therein will not collect but will flow therethru. The numeral 97' and 98' refer to the countersunk upper section of each hold to improve the collection of the oil, provent overflow and account for variations in the alignment of the holes 97 and 98. The numeral 99 refers to a s in the base of 71', 99' to a ducting therein leading to an oil pump for returning the oil to the system. A tray or fence 96 is provid surrounding work holding jig 35 to catch chips or waste falling of or flowing from the work. Said tray may be, automatically pivoted removed, turned or dumped to clean out the waste therein. Anothe alternative may be to run the assembly at 35' thru a bath of sol to remove allwaste, oil, etc. The letter F refers to filters in lines 97 and 98 to filter the collant or oil flowing therethru.

Fig. 18 and 19 show a work holding ing conveyor which, unlike the aforedescribed automatic conveyor units does not ride on a trackway, but travels along a continually moving conveyor belt 107. Fig. 18 is an end view of said unit on the conveyor 105 and Fig. 19 an isometric view thereof. The conveyor work-holding unit may be designed with any desired degree of complexity depending on the desired degree of automatic manufacture, which in turn would depend upon the particular production requirements and the number and type of machine tools flanking the production line. The unique feature of this arrangement is that characteristics of the conveyor unit 100 such as its shape, may be used to (a) detect the unit and automatically move it off the conveyor to the machine, (b) preposition the unit and work held therein respective to the machine and (c) act as a holding member or intermediary holding member at the machine thereby prepositioning the work and (d) as a means of referencing the work at the machine.

The work-holding unit is shown as a cubicle 100 open at the top with a flat bottom 101 which rides on the conveyor 107. The cubicle 100 may be designed per se with a rectangular opening therein having and/adjustable or automatically operatable clamps, C1, C2 and C3; or may have any shape convenient to move along on the conveyor and to hold a product or products.

In the device of Fig. 18 and 19, I show a work holding and conveying unit 100 having automatic and adjustable clamps C1, C2 and C3 driven by servo motors, or solenoids MC1, MC2 and MC3 (not shown). The clamps may be shaped to the contour of the face of the product. They are shown as flat plates. They may also be made of a flexible material such as rubber. If the work in process does not require heavy machining operations and can be referenced respective to the jig 100 by being forced against the jig inner walls by the clamp. The faces of the clamps are also preferably removable to account for differently shaped work to be held.

Two types of production line set-ups are possible using this work-holding conveyor arrangement. They are (a) a production line having an array of machines and machine tools adjacent to the conveyor 107 and an array of individual jigs carrying work in process which is held in each jig 100, and transported thereby from one machine to the next automatically conveyed to each where an operation or sequence of operations are performed thereon. Said set-up is inflexible in that each machine must be adjusted to perform a specific operation on the jig

hold work. However, it is low in initial cost. More important is that each station
machine ~~could be~~ designed to accomodate the outside dimensions or shape of the
jig 100 and as such may be easily adjusted to alter its operation on the work.
In other words, the feed, speed and degree of travel of of the cutting tool are
the only variables which ~~must~~ J.L. need be changed for operations on different J.L. kinds of work in
process, not the means of handling or clamping the work at the machine, whereas
the conventional transfer machine is designed only for a specific product;
(b) a production line having an array of machines flanking a conveyor and a ser-
ies of work holding jigs 100 riding on said conveyor which contain means for (a)
selecting predetermined stations and (b) commanding action of the tool at each
of said selected station on the work held thereby.

Fig. 18 shows the more elaborate design (B) for automatic production whereas
Fig. 19, the isometric view; shows design variations which could be applicable
to either (A) or (B). Both Fig. 18 and 19 show photoelectric cell means of stat-
ion or conveyor jig 100 identification. Needless to say, mechanical identifica-
tion means involving the closing of switches at the station by the work carrier
may also be utilized to advantage for this function. The simplest mechanical means
involves the tripping or closing of a limit switch projecting outward from the
conveyor wall which is thus actuated by the passing of the unit 100. The action
would cause the ram to push the conveyor unit off the main conveyor 107 onto the
station platform with sufficient velocity to butt against the stop or wall S.
Once at the station a second limit switch 115 is actuated by the movement of 100.
Switch 115 is in circuit with prepositioning and or clamping or holding means at
the machine adapted to operate on the unit 100 prior to machining operations on
work therein. As all work held in 100 may be easily referenced respective to the
bottom and side walls thereof, said work will be referenced or prepositioned res-
pective to the machine tool when the work-holding unit 100 is rigidly held at the
machine in a prepositioned attitude or position at the machine. The clamping or
holding means at each machine may be standardized and (or) similar if all the work
holding jigs are standardized and (or) similarly shaped. The problem thus becomes
one of designing or adjusting the jig clamps C1, C2 and C3 to hold a particular
piece of work at the correct attitude and position it so that it will be referenc
ed respective to the walls or characteristics of the shape of the outer surface
of 100. The station machines MT, etc may then be pre-adjusted or command operat
to perform a particular operation or sequence of operations on the jig held work

In the warehousing or ~~stor~~ storage of manufactured goods a prime factor of cost is incurred in materials handling. The direct labor of transporting anditem to be stored into the storage area and stacking or otherwise positioning it on its particular storage shelf, rack orpalletized arrangement and picking it up and removing it when needed for processing orshipping has been greatly reduced by the use of mechanical materials handling equipment such as lift trucks, conveyors, cranes, etc. However, said materials handling equipment requires direct labor for its operation and at leaste one man must accompany the equipment to and from the storage area, position it in front of the stored item, lift and remove it. This not only requires time for human reactions to start such required functions as seeking, finding, prepositioning the materials handling device, judging and moving the equipment, etc, but also requires the close and full time attention of an operator.

I hereinafter present a new and improved materials handling system whereby materials are handled to and from the storage area in an efficient orderly manner with a minimum use of human effort. Movement of materials to and from a stroage area may also be rapidly expedited to andfrom a storage area at a rate which is faster than any accomplished by human attended equipment.

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9M Modifications of and
the aforedescribed machine control components may be utilized to advantage
in storage operations wherebye products or raw materials are palletized, boxed
or can be made into a shape which is easily stacked or arranged on shelves and is
capable of being picked up by a grabbing device or fork. The system to be des-
cribed is particularly useful in completely eliminating the necessity of the man
traveling to and from a storage area to either handle or direct handling of a
product for its storage or removal. The entire system is automatic and may be
directed from a remote location. The system is of particular value where a rack
or shelving system is provided on which to store and stack packaged items or
pallets, or items stored in open boxes said storage system extending not only laterally in the X, Y plane but
also a number of tiers in height. Fig 24 shows such a system wherebye said
racks or shelving are devided into a number of unitized storage volumes. 150 Each
volume may be identified by an X, Y and Z coordinate. The X coordinate will de-
termine the aisle in which the unit volume is located, the Y coordinate the floor
location in that aisle and the Z coordinate, the number of unit volumes high the
particular volume is located. By utilizing some of the aforedescribed components
and an adjustable quickly settable command device for locating any particular
unit volume, the monorail or bi-rail overhead conveyor systems combined with the
verticle column 23 may be utilized to automatically store and remove palletized
or boxed utilizing forks, rams, grabs, etc. This may be accomplished automatical-
ly in a manner involving a minimum amount of labor, handling, or attention.

For accessibility, the unit storage volumes are arranged in rows of Rx_1, Rx_2, etc.
an aisle between each two and accessible from an end row of aisles Ry_1, Ry_2, etc.

Assuming that the storage area is designed as in Fig. 24 with rows of multi-
tier racking volumes 150 each accessible to an aisle Rx from an end aisle Ry by
the overhead crane column and lift of Fig. 24, let the following letter and sym-
bols designate travel of said materials handling device to and from a storage
volume. Y is assumed to be the distance traveled along the outer aisle by the
dolly and column and Y_1, Y_2, Y_3, etc will therefore designate the aisles 152 be-
tween the racks numbered for identification from one end; X is assumed to be the

distance travelled along any aisle, and X_1, X_2, X_3, etc. the X or floor location of any particular storage volume or section of shelf 160; Z, the height travelled by the lifting platform or forks 163 and Z_1, Z_2, Z_3, Z_4, etc. the height location in number of bays above the floor of any particular volume 163. The letters R' and L' refer to right and left hand sides of the aisles Rx of Fig. 23. The letter Y' refers to the distance travelled by the forks 153 from the aisle stopped position of the conveyor in towards the bay to under the pallet 154 or tote box therein. If other means grabbing or holding the work are used, Y' will refer to that action of said conveyor mechanism from the aisle stopped position of the column 23 to the storage bay to effect engagement or lifting of the load from the bay. The letter Z' refers to the lifting or verticle motion of the pallet or box 154 necessary to effect its removal from the racking by the forks 153. The letter -Y ' refers to the motion of the forks 153 in withdrawing from the storage rack a degree into the aisle sufficient to permit further movement of the conveyor down the aisle. The letters -Y,-Z and -X refer to travels of the load on the forks or the forks empty from the aforementioned aisle position down the aisle Rx and along Ry, if necessary to a position where it comes to rest pending further commands or prior to depositing a load.

Z' vert movement
Y' lateral
X' long mov.

The actions designated by Y',Z',-Y' and -Z' may be similar for the act of (a) storing a pallet or (b) removing one from the storage bay provided that all the unit storage volumes are similar in diemension and the pallets or boxes are the same shape or can be centered on the forks and in the storage volumes. As such, these motions may be made inherent in the system by the provision of a sequence command device CD hooked up to initiate the desired sequence (a) or (b) upon arrival of the forks 153 opposite the desired bay. As an illustrative example, assume that it is desired to remove a palletized load from a storage volume located at Row Ry_4, aisle Rx 6 and 3 tiers up (Z = 3). The predetermining counter is dialed 4,6,3 and the command the command device CD is set for (b), removal of a load. The switch 159 is closed, My starts up and the counter receives pulses counting aisle locations along Ry until 4 are passed (when the bi-rail system of Fig. 4 is utilized). A switch is thrown opening the circuit with My and closing that with Mx after 4 counts. The [illegible] then run to 6 down aisle 4 whereupon the conveyor is opposite the X,Y position of the desired volume 163. Mx is then stopped by a switch opening its circuit with the power supply and Mz starts up and drives the forks up 3 bays. When the counting device controlling Mz counts out 3 bay locations (in manner to be de-

scribed) a switch in the counter opens the circuit with Mz , closes a circuit with a device braking the upward travel of the forks 153 and also closes a circuit containing the power supply and the command device CD, in particular that part of CD which will control the action of the forks necessary to remove a load from the bay which it is opposite . (Y',Z',-Z'). The command device CD then controls the action by counting the rotations of the motors My and Mz and controlling them to drive the forks to under the pallet, lifting the pallet a small amount, and withdrawing the load sufficiently out into the aisle to permit travel of the forks in the X direction. Upon completion of the action designated as -Y' , CD shuts off and, at the same time Mx starts up under control of a predetermining counter which again receives pulses as each bay is passes along Rx_4. When Ry has been reached, Mx is shut down and braked and My drives the conveyor in reverse to the point of origin or to any preset desired location for unloading or further storing of the load on the pallet. The entire sequence of actions in their occuring order and designated by the aforedescribed letter designations is: Y (to R=6), X (to x = 4), Z (to z =3), ⊕Y',Z',-Y' (under command of CD), -X (to Y =1) , -Y (to point of origin or any other designated area under control of the predetermining counter computer system). 19

Several points concerning the command system are noted prior to detailed discussion of the schematic control diagram of Fig. 25. It may be required to store a number of palletized loads from , for example, an unloading conveyor via the unit carrier 22 to a section of unit volumes 153. This may be accomplished in a given order , for example at $X1,Y_4$ the Z volumes 1,2,3,4,5 and 6. The action may be accomplised by using enough counting circuits to count out z_1,Z_2,Z_3,Z_4 etc. following the repetitive sequences of 94L X1,Y 4or may be accomplished by lock-in switching circuits which will repeat the movements to and from X_1,Y_4 and a stepping switch arrangement which adds a digit to the Z counter each time. The provision of counting devices linked via switching to each other for each of the following motions ⊕,Y,X,Z,-Z,-X and -Y and rapid means for setting said counters, will permit the dispatching of the conveyor unit to any storage volume and its travel therefrom to any other volume or area in the system. In removing the load from its storage position, if a steel tote box or pallet is utilized to hold the load, it may be removed by the provision of an electro magnet movably mounted on the platform 153.

94L

Palletized or boxed material may be rapidly moved to or from a storage area of the type described in one of several manners by the presetting of a predetermined counting device which by the receipt of position locating information, controls the motion on the conveyor. One type of predetermining command device is shown in Fig. 25 as comprising at least three predetermining counters Pr Cx, Pr Cy and Pr Cz, each adapted to open and close one or more switches (therein) for controlling the motor controls Mx, My and Mz. The predetermining counters may comprise mechanical counting mechanisms or electrical counting switches, usually arranged in banks which are actuated by electrical impulses received by one or more positions locating devices.

One of several means of operation may be employed. (a) The entire motion of the conveyor and forks may be under command of a presettable predetermining counter or counters which count the rotations of the motors Mx, My and Mz, the revolutions of which indicate the position of conveyor unit along any row or aisle, and opposite any located storage volume. (b) the conveyor movement to opposite the storage volume may be controlled by the use of predetermining counters which are triggered by electrical impulses from switches closed by physical means locating the position of the column 23 and forks 153 as in Fig. 4 and 5, (c) the predetermining counters may be triggered by photoelectrically operated switches mounted on the conveyor which are closed after the return of a light signal to a photocell as in Figs 7 and 8, (d) counters PrCx, PrCy and PrCz may all be triggered by a universal switch 156 protruding from the end of the forks as in Fig. 25 and closing a circuit as it strikes the crossbars 151 and 152 of the storage racking. Once opposite the desired storage volumes the forks 153, grab, or platform may be automatically moved to and from the racks 152 in the act of either moving palletized or boxed items thereto setting the load down and storing thereat or removing said palletized or boxed item therefrom. This action may be accomplished in one of several manners, (a) by the use of command device C.D. which is triggered or started up by PrCZ when it (PrCz) shuts down MZ, and indicates that the desired travel of the forks to be opposite the desired volume 150 has been reached (b) by the automatic starting up of My as in (a) when a switch closes in PrCz after it has counted out the proper Z travel positioning the forks 153 opposite the desired bay) and the driving of the forks towards the racks which are further controlled in the act of moving to or from the storage volume by the use of

limit switches situated on the forks and closing with the engagement of the pallet or racking. (c) by the use of a photoelectric cell 68 and light source 69 situated at the end of forks 153 or platform to scan the product and (or) racking. and which controls motion of My and Mz, (d) by combinations of (a) to (c).

The command device (CD) may be any mechanical or electrical device which will open and close circuits with the motor My and Mz after a specific number of rotations of said motors, and in a sequence which will drive said forks in either of two desired sequences (a) the act of My moving the forks 153 in under the load, Mz driving the forks upward a sufficient degree to lift the load to clear the racks and My reversing the travel of the forks to carry the load to an aisle position whereby the forks and load will clear the racks in their travel parallel thereto and (b) the act of My moving the forks 153, having the load thereon, to said volume, Mz lowering the forks a degree below which the load pallet engages the top of said racks and comes to rest thereon and My reversing the travel of the forks to remove them empty therefrom to the center of the aisle Rx or a degree sufficient to clear the racks in further travel parallel thereto. 16

For manual setting of Pr Cx, PrCy and PrCz it is preferable to use a dial operated switching device similar to the dial-switch utilized in the conventional telephone, which may be used to cause a series of pulses of current (depending on the number dialed) to actuate a solenoid, setting up the predetermining counter or may be used to close relays in a bank as in a telephone control circuit which may be used as the predetermining counting device. Each signal operated by the position locating device may be used to open one of said relays and the opening of a preset groups of said relays may cause opening of a switch in circuit with the particular motor control (Mx, My, or Mz). Predetermining electrical counting and control devices are known to the art and may be of various designs. For this reason, in the diagram of Fig. 25 I diagramatically show therein as a boxes which are electrically connected to each other and to C.D. for the purpose of starting each to operate in sequence. (i.e.- when the counter Pr Cz runs out and the conveyor assembly is opposite the X, Y location of the desired bay, it closes a switch therein which closes a circuit containing Pr Cz

911 L 31

which command Ad

thereby starting up Pr Cz which commands travel of 153 when Pr Cz runs out at the instant the forks 153 are opposite the desired bay it opens a switch in circuit with the Px control and braking means and simultaneously closes a circuit with C.D. which initiates the further predetermined actions.

The command device is shown in Fig. 25 as being devided into two sections C.D. and C.D.'. C.D. is used to designate that part of the command device which controls the automatic action of the forks 153 traveling empty from the aisle opposite the bay 150, to said bay, picking up and removing the palletized load therein; C.D.' is that part of the command device which controls the automatic action of the forks 153 carrying a load from the aisle position (opposite the storage volume) to said volume, setting down the load and returning empty again to the aisle position. Either C.D. or C.D.' is preset or thrown into the circuit with the predetermining counter PrCz at the dial switch 164 after PrCz has been dialed by the use of said dial switch or by push button switches 164' closing a circuit and actuating a solenoid in C.D. to close a switch locking it into the circuit with PrCz.

The letters PrC'y, PrC'x and PrC'z designate predetermining counting devices which are used to control the movements -Z, -X, and -Y of the conveyor assembly out of the storage area to dispose of or pick-up another load. PrC'x, PrC'y and PrC'z may be set by dialing 164 or may be of such a design that they automatically become set by counting up with the uncounting of PrCx, PrCy and PrCz.

In Fig. 25, the switch 155 which is located on the end of fork 153 is used to count the number of storage bays 150 travelled in the Z direction by closing a circuit with the counter PrCz everytime the switch arm 156 strikes a horizontal crossbar 152 or shelf. If switch 155 is a universal switch which is normally open and closable everytime the forks pass a storage unit volume 150 and arm 156 strikes either 151 or 152, then 155 may be used per se to locate the preset or desired storage unit volume. In this arrangement, 155 would be connected to the predetermining counters thru PrCy permitting the aforedescribed station seeking actions. The switch 59 may be eliminated if the forks can be made to always travel opposite the racking so that 156 will be deflected with the X,Y or Z motion thereof. If the monorail system is utilized, this is a matter of positioning the trackway so that the forks, when retracted, will just clear the racking. If the bi-rail conveyor car (see Figs. 4 and 9) is utilized with the switch 155, the aisle-stopped position of the carriage 22' would be such that the forks 153 would just clear the racking so that the switch arm 156 is deflected with movement of the forks thereon.

crossectioned
Fig. 26 is a partially cro ~~ss~~ ioned, partial side view of a fork or plate
form 153 showing a compression or limit switch 161 mounted in a cavity 162 in
the top of the forks to project upward therefrom and be closed in the act of the
forks being moved to the bottom of a pallet 154 when a pallet or load is placed 4
thereon. Said switch may be used in a system (a) not having a command device to
stop the Z' travel of the forks a short time after it 161 is compressed and start
up by initiating the Y' motion of removing the forks with the load thereon or 8
(b) in a system having command devices C.D. and C.D.' to indicate whether the
forks are empty or a load is thereon. If a load is thereon when PrC is set by
dialing 164 then the computer C.D.' would be locked in with PrCz and the storing 11
sequence would occur after the counting out of PrCz. The numeral 163 refers to
a compression operated switch projecting from the end of 153 or possibly from the
end of 156 which may be used as a safety device. The switch 163 may be used for
example to indicate ^qut^ that an item is already located in a particular unit volume in
the event that the operator makes a mistake and dials the work volume in which to
store. 163 may be connected in circuit with a solenoid actuating a switch shutting 17
down the motors in the system. 18

Fig. 27 is a partial diagramatic view of a predetermining counting system
utilizing a photoelectric cell 68 and light source 69 to detect station or bay
locations. A small reflector 70 is positioned at the same relative attitude res- 20
pective to each bay on either the verticle 151 or horizontal 152 cross racking
facing the ~~bays~~ ^9H aisles^ Rx and Ry so that the beam from the light source 69 may be reflect-
ed thereby back to 68 and close a/switch in photoelectric control 163 signalling ^9HL relay operated^ 24
the predetermining counters which have been preset by dial switch 164. The photo-
cell 68 and light source 69 are preferably mounted in a single casing at the side
of column 23 as shown or within 23 between the forks and positioned so that the ^9HX if said column is adapted to move up and down with the forks, see Fig. 4) 9HX^
light beam may project against the face of the racking 151. 68 and 69 are more pref-
ably mounted on forks 153 to move up and down therewith. if 23 is fixed vertically 9HX
Fig. 28 is a diagram of the photoelectric control circuit which amplifys the
signal in the phototube reflected off 70 from the light sources 60, and the relay
164' actuated thereby which is electrically connected to the means actuating the 33
predetermining counter every time it, 164', is actuated.

Fig. 29 is a partially crossectioned view showing means setting the predetermining counter PrC from a location which is remote from the individual work carrier column 23. The numeral 169 refers to a wall or upright positioned below said overhead trackway to be adjacent to said verticle work supporting column 23 when the latter is at a starting position or parking area awaiting dialed command signals. Electrical brushes 166 sweep over the surface of contacts 167 projecting from 169 making electrical contact therewith while the conveyor is parked or at a standstill thereat. The dial switch 164 may be located at a remote distance from 169 convenient to the operators reach. Via the brushes 166 and contact bars 167, it 164 becomes electrically connected with PrC which is mounted in the conveyor assembly as shown. As such, 164 may be used to preset PrC by acting as an intermittent switch in circuit therewith and, for example, actuating a solenoid or solenoid therein to set-up PrCx, PrCy, PrCz.

The numeral 70a (Fig. 28) refers to a second reflective marker positioned adjacent to the marker 70. It is utilized to effect more precise stopping of any moving part of this invention which is controlled by the photoelectric cell 69 and light source 68 as follows. The reflection of the beam from 69 from 70 opens a 74x thru the relay 164' sends a pulse or current circuit to a device such as a solenoid which either slows or brakes motor Mx (or whatever motor is driving the unit past 70) a sufficient degree to be precisely stopped at a desired position upon the passing of 70a. The same effect may be attained by utilizing the reflector 70 just before the one desired at which to stop the unit, to initiate action slowing down the driving motor.

Both the monorail and birail conveyor units are shown in Fig. 24 for the purposes of illustration. The forks 153 of the monorail unit (foreground Fig. 24) are shown drivable up and down by a chain 157 and sprocket driven by Mz, and drivable in and out (laterally respective to 23) on a mount by My which rotates screw 42' which longitudinally moves a collar 43' secured to the mount 153'. The numeral 154' of Fig. 24 refers to a tote box in a bay with a pallet shaped bottom permitting it to be picked up by forks 153.

Jerome H Lemelson

after it is secure at the station. The jig 100, since its external dimensions permit ease of conveyance and ease of handling, transferring, propositioning, clamping, removing, etc, is thus a means to a very flexible system of automatic production whereby a variety of different products may be handled automatically by simple adjustments or changes of the station machine tools. Means handling the unit 100 (to and from each machine) may remain fixed and need not be altered for a variety of products.

Fig. 18 shows an elaborate conveyor unit 100 design having a computer 47 mount- ed in a base compartment thereof below the clamping section. The computer 47 may be a timed sequence-command device and is utilized to both select stations and com- mand operations of the machine tool by making electrical connection with the machine base 71' or back stop "S" as shown in Fig. 14. Contacts 84 and 87 which mate when the unit 100 is secured at the machine electrically couple the two together.

Station selection is attained by the use of reflective strips XC on the con- veyor guide or wall 108 which are scanned by a photoelectric cell 68 mounted on the wall 101a of the unit 100 and positioned to scan 108. When a predetermined station has been identified by computer 47, a solenoid actuated ram 103 powered by a self contained battery or one mounted in 47, projects its ram operated face plate 104 against the side of 108 forcing the unit 100 off conveyor 107 onto roller conveyor 110 leading to platform 71' under the operating section of the machine tool MT. When the conveyor unit 100 reaches the bed of the machine it strikes the back wall or stop "S" thereof (is further propositioned after closing the inward movement of the side clamps 73 acting against the side walls of 100) and in doing so it closes the limit switch 115 mounted in the base 71 which is in circuit with the machine situated clamps 73. Said conveyor unit 100 is further pro- positioned by the inward or lateral movement of the side clamps 73 and by the use of end clamps (shown as the cam shaped clamps 112 of Fig. 19 which project against the rear face 101a of 100 and force the cubicle against S. Cams 112 are mounted on laterally extending shaft 112' which is rotated the required degree by the use of spur gear 114 also mounted on 112' and spur 114' which is slidably mounted under conveyor 109 and (or) 71' and moved longitudinally by a solenoid actuated

B a delay perid after the closing of switch 115.

Upon the completion of machining or other work on work in process hold in 100, the clamps 73 and 112 are automatically returned to their release or unclamp-ing position by limit switches controlling their solenoids which are actuated by the machine motion in the act of withdrawing from the work or by the computer commanding the sequential operation of the tool, if such is used. Said action is followed by the longitudinal outward movement of ram 111 (solenoid or hydraul--ically actuated) which pushes the unit 100 away from the machine and back onto conveyor 107. While not shown, this action of pushing or moving 100 back on the conveyor would be delayed in the event that there is another such unit carrier on said conveyor opposite said machine. A photocell relgy electrically connect-ed to open the circuit of the solenoid actuating 111 when another 100 unit is thereopposite, may suffice. Also not shown but essential to smooth operation where the cycle time at each machine varies, and each unit 100 contains the same work in process, are means before each station to stop the conveyor 107 should a unit 100 approach said work station while work is held thereat. Said means may comprise limit relays in circuit with the 107 conveyor driving motor and opening said circuit when said switbh or photocell detects the presence of 100.

The numerals MC2 and MC3 refer ro servo motors or solenoids driving the work
GHL in and out respective to 100 thru GHL
clamps C2 and C3 / for examples 102 and 105, ~~to~~(a spur or worm gear train between MC2 and C2) and the numeral 108 to a door in the wall 101B opposite command device 42 permitting quick removal and replacement of a command recording therein.

Fig. 19 shows a simpler design of the work carrier and the associated con-veyor detection appartus. A photoelectric cell ₵ combined with a photoelectric control unit actuating a relay) is mounted on the conveyor rail or wall 108 to scan across the conveyor. The cell is provided with its own light source 69 and detects the presence of 100 or 107 by reflection of light thereoff, thereby act-uating a relay closing a switch in the circuit with solenoid 103 actuating a ram (not shown) which pushes 100 off 107 and on to 71'. Said relay is designed so that it will actuate 103' only after the photocell 68 has been twice actuated so that the unit 100 may pass back onto 107 after the station ram 111 has ejected it and will not be disturbed thereon by 103'. An alternative is to reflect light from 69 off a reflecting strip 70 situated on the side of 101a which by use of a delgy between the energizing of 68 and the actuation of 103' does not

B again cross the path of the beam of the box 69 after the unit has been ejected from the machine.

The numeral 113 refers to a reference area on the surface of work W preferably machined or otherwise formed thereon utilized where needed as a reference surface for a cutting tool or probe guiding the motion of a tool. If reference surfaces 113 are formed or machined on more than one surface of W so as to define the position of W in the X, Y and Z planes, then the work holder unit 100 need only be used as a conveying medium for W and the work therein may be located at the machine. The numeral 113' refers to a reference hold in W, one or more of which may be used for positioning, referencing and (or) handling purposes. The numeral 109' refers to end of the guides 109 (leading to the bed 71' of the station machine M) which are beveled inward to guide the work carrier 100 to the bed 71' in the event that it over or under rides the station position on 107.

97L

Predetermined Command Computer

The aforedescribed production operations may be automatically accomplished in one of serveral manners. The entire operation including motion of the work in the X, Y and Z directions and any needed tool or tool bed motions may be controlled in its entirety thru a series of switches in various circuits with a power supply and the motors driving said wokk clamping device work and tool in the required directions respective to each other, said switches accomplishing this end by being urged to open and close in the correct sequence for the proper time duration to accomplish the required results. This may be accomplished, by providing a sequential array of switches and circuits with adjustable preset time delays in each. A more versatile predetermined command system is one utilizing a recording medium for opening and closing the various operating circuits in a desired sequence and for a desired period of time. Magnetic recording means have been used to open and close a series of circuits in sequence and involve merely the recognition of a signal by a magnetic pick-up or head riding on a continuously moving tape or wire, said signal being amplified and utilized, for example, to fire a thyratron tube and actuate a relay closing or opening a switch. A more preferable arrangement from the point of siplicity and interchangeability is to employ a punched card or tape driven at a constant speed in contact with a series of arms or feeler elements riding thereover.

For particular production problems, a more practical approach (than that of having the entire sequence of production operations solely under the control of a command computer), is to command parts of the cycle when said work conveyor is there opposite and combine said action with reference or locating points along the production line with a means for detecting said locations, to either supplement or initiate said commanded motions. In this way, tendencies for errors to accumulate in the mechanical-electrical system due to free play, slippage, etc., are minimized or eliminated. Control may be affected by (a) starting the operating and command recording to run only weh needed, for example, at the station or machines, by opening and closing its own driving motor circuit at each station by using limit switces motivated by motion of the work conveyor respective to the conveyor system; (b) permitting said recording to run continually and providing sufficient dwell or extended periods in or between each commanded action to permit the completion of automatic actions or sequnce of actions necessary to complete the operation. Several of said automatic actions ~~permitting~~ JHd.

may be,
have been described. They may for example ; the limit switch controlled action of stopping and aligning the work or work holding unit at the machine tool base 71'; automatic clamping, grabbing, holding or moving of the work or work holder, at the machine; automatic travel of the powered work conveyor unit from station to station; automatic braking and prepositioning of said work conveyor unit; automatic picking up and dropping or ejection of the work from the work conveyor platform or clamps; automatic removal of machining wastes at the machine or from the work conveyor unit; automatic inspection operations including probing actions at the machine which are either preset or commanded as described and provided with feedback for tool corrective measures(said probing action may be actuated by a limit switch triggered by the action of the tool returning to a neutral position following its operation on the work); automatic movement of the work holding platform 35 from one side of the conveyor to the other, etc. The production cycle would thus consist of a series of commanded actions directing movement of the work to the stations , machines and possibly movement of the machine tool (if it does not have its own command system), intermixed with a series of actions which are either commanded or automatic and automatically initiated by the motion of the work conveyor unit respective to switches or photoelectric switching devices positioned in the system.

Fig. 20 is a diagrammatic drawing of the punch card operated sequence command computer and Fig. 21 a wiring diagram of the computer and electrical devices which may be controlled thereby. The command recording, representing the time durations of the rotation of the various motors of the system or the opening or closing of solenoid actuated switches, is shown as a series of cutouts in the punched card 119 . Said card is driven at a constant speed between frictional or toothed rollers 121 and 121' rotated by motor 125. Feeler arms 122 ride over the card in its longitudinal travel , in and out of the recesses or cutouts 124, HL therein , and are pivotally mounted to open and closes a series of switches 122 which completes or breaks circuits with motors Mx, My Mz, Mr, etc. (associated with the work conveying units 22 or 100) and motors Mt, Mtx, Mty, Mtz, Mtbc, etc. associated with the machine tool, tool bed, clamps, etc. If the speed of travel of the card 119 relative to the feeler elements 122 is constant and accurately controlled, the length of the slots or cutouts 124 in the card 119 will determine the time of operation of each motor and hence

JHL tool, work

6 the degree of motion of the too k,inspection device,etc. If the starting
and stopping characteristics of ...on motor are considered in designing the
cutouts 124, distances moved in the x,y and z planes under command, may be
maintained to a specific accuracy. If this accuracy will suffice for the entire
operation ,the command system per se may be used. Due to free play,and the
various other errors into the system and command computer, most manufacturing
operations on work in process utilizing the components of this invention will
require the limit switches,photoelectric devices,etc. for locating purposes
and to initiate other automatic actions.

The command computer of Fig. 20 ,designated by the numeral 47 is mounted
in a casing comprising end walls 116 a and 116b .A powered roller 121 is
supported in bearing by the sidewalls 116 and is rotationally mounted thereba-
tween below idler roller 121' in a manner permitting a card 119 or tape to be
driven therebetween. The numeral 125 refers to a motor driving roller 121 thru
bevel or worm gears 126 and the numeral 125' to a housing in which a motor
control is mounted for accurately controlling the speed of motor 125 and keeping
it at a constant value. There are a number of such controlls available to the
art and it is therefore not considered necessary to go into the details thereof.
The card 119 is placed thru the opening or slot 118'in the wall 118 ,is driven
thru rollers 121 and 121' ,is guided laterally by the walls 116 or projections
thereof and supported in its longitudinal travel thru the computer on base 119'.

Fig. 21 is a schematic electrical diagram of the command computer of Fig.
20 and the various electrical components of the system. The feeler of switch
arm elements 122 controlling the switch SMx which is in series with the motor
Mx and the power supply are referred to by the letter F and the designation
for the particular rider arms are FMx,FMy,FMz,etc. The switches they control
are referred to as SMx,SMy,SMz,etc and are in series circuit with a power
supply thru the brush elements 27 and the motor controls (including braking
devices) for motors Mx,My,Mz,etc. Although only five switches are illustrated,
others are inferred by the use of arrowheads on the leads to particular switches,
solenoids,motors associated with the conveyor, trackway,station machines,etc.
The switch 59 is shown connected to Mx and is such a design that it may bypass JHL

3.2 JHL

forming, molding,
with operations other than maching such as/assembly,finishing,inspecting machines
...applicable to a variety of different products by the use of JHL

31k for a period which is greater than required to drive conveyor unit column 23 or crossbridge 52 to the desired station, then it will be guaranteed to reach the station and may be stopped precisely at the station by either the pin actuated switch 59 or the photoelectric cell arrangement of Figs. 7 or 8.

The numeral 159 refers to a starting switch for turning motor 125 on and off. The numeral 86 refers to the contact coupling arrangement between the conveyor work holding platform 135 or unit 100 and the machine tool which has been described and illustrated in Figs. 14 and 15 and is used to convey electrical command signals from the computer when mounted in the conveyor unit to the machine or machine tool servos, MTr, MTx, MTy, MTz, MTBC, etc. The letters MTBC refer to servos or motors driving clamps or holding devices at the base of the machine or machine tools. Also shown in Fig. 21 are inspection or prepositioning probes designated as Ix, Iy and Iz, C, etc. with their associated probing heads IPx, IPy, etc., Each of said probes is electrically connected to an affiliated computing devices ICx, ICx, ICz, etc. which receive signals from the computer 47 indicating the desired motion of their probes for an acceptable product. The probe computers ICx, ICy, ICz thru one of various electrical means, record the time durations of the signal from the computer 47 and thru the medium of feedback (indicated by the double arrow designation to Ix, Iy, Iz, etc) control the motion of MTx, MTy and MTz. A sufficient dwell in the recording on 119 between the next command signal may be provided, to account for the operations of the machine tool under command of the feedback-probe-computer arrangement to account for more than the longest expected cycle or, this variable may be allowed to run to completion while the computer 47 shuts down. Shutting down of computer 47 may be accomplished by a self excited switch 159' which is urged to close upon the completion of the signals to the command computers ICx, ICy and ICz which thereby start up 47 again by actuating 159' when they have completed their operation. The switch 159' is preferably also solenoid operated so that it may be urged closed by a signal from said computers.

Fig. 21 shows several components which may duplicate functions. These are illustrated in the single diagram to show that they may be utilized at any point thruout the system and to show their position in the circuit. It is noted that a number of the components of Fig. 21 may be omitted for specific production operations or the circuit may be made more complex with additional stops, servos, probes, positioning, locating, feeding and clamping devices; devices associated with operations other than machining such as forming, molding, assembly, finishing, inspecting machines which now become applicable to a variety of different products by the use of

37'

7H7 03 of the aforedescibed devices and the highly versatile systems described for
the handling of work in process.

The computer 47 may be of various designs(the function of which are not necessarily based on the time duration of a signal such as the device of Figs. 20 and 21) to control the various operating and servo devices associated with motions of the work and machines. A computer utilizing electrical counting devices to count the revolutions,or fractions thereof, of said conveyor and machine tool driving motors from a base or zeroed position is conceived as a suitable application for the command functions. Counting circuits consisting of banks of presettable relay switches have been used to direct the motions of devices powered by servo motors,etc. One conceived device or system as applicable to the components of this invention which would permit a very flexible degree of manufacture and could be easily changed in regards to command sequence would comprise (a) ~~a signal input section which would set up the desired sequential~~ order of command signals from a recording by presetting (b) banks of counting relays which, at the proper instant in the cycle, would count out the revolutions of each of said servo devices (Mx,My,Mz,MTx,etc.) ,open or close a switch when the preset count had been reached ,thereby stopping or braking said motors. In this manner, the degree of travel of the tool or work,which is a functions of the rotation of its driving motor could be preset and predetermined to perform a specific operation on any work which is referenced respective thereto. The signal input section could ,for example, be the computer of Fig. 20 with nine of the switches 123 being arranged to represent the digets 1 to 9 and one representing zero, and electrically connected to close the desired number of relays in a bank. If holding relays are utilized, the digits 1-10,10-100,100-1000,1000-10,000 etc. may be simulated or set up in different banks to count out,for example , a four diget number of revolutions of the particular servo. The feeler elements 122 falling in and out of slots in the card or tape 119 could by the use of signals generated with the closing and opening of the switches 123 open a circuit with a bank of holdable relays and by current pulses from the switches representing the digets closing set up or hold a specific number of said relays.If,for example, a current pulse could be generated by rotation of the shaft of the particular servo motor with every revolution thereof, and every revolution moves the tool .001 inches, then the desired motion of the tool may be controlled by

Numerically controlled

7HX

to open

arranging the bank of relays. en a circuit with the particular servo
motor and its source of power or close a circuit with a braking device which
is calibrated to brake said motor a desired period after being actuated, said
action taking place after the last of the preset number of relays have been
opened. For example, if it is desired to move the tool .008 inches in the
X direction, the bank of relays controlling the X motion of the tool from a
zeroed or other position known to the command system would be set up by the
first 8 of the switches 123 falling into slots 124, closing and by providing
means electrically connecting each of said switches 123 with a corresponding
relay in the bank, the first eight of the bank relays may be closed. The bank
circuit, termed a register, can store information (numbers) set into them
for indefinite periods, and as stated, may be used to count by decades in
driving
the decimal system. By shunting the signal braking or stopping the motor MTx
thru this bank, said action may be so initiated upon the completion of the
117 bank
count if the relay/is such that its opening will (a) either open the circuit
with MTx or close a circuit with the device braking MTx. Upon the receipt
of 8 pulses indicating 8 revolutions of MTx the circuit with MTx is thereby
opened and (or) the braking device is energized. JHL.

of the aforedescribed devices [illegible] highly versatile systems. described
for product handling.

The computer 47 may be of various designs other than that of utilizing
the time duration of a signal to open and close circuits with electrical
servos. For example, another method applicable to controlling the servos
of this invention utilizes a computer and punched card or tape to relay
information in the form of signals (representing numbers in the decimal
system) to banks of counting relays ,each bank representing a decimal posit-
ion in the decimal system which counts a revolution or groups of 10,100,1000
etc.of said revolutions of the particular servo motor or driving mechanism.
As such ,said counting relay circuits may be used to control the x,y,z and
rotational motions of the tools or work respective to the tools. For,example,
assume that the motor MTx is to be directed to drive the cutting tool of an
automatic milling machine a distance of 2.357 inches from a zeroed or at-rest
position. in the x direction. Assume also that every revolution of the motor
controlled by MTx is such that motion of the tool will be .001. inches in the
x direction with the completion of said motor revolution. To attain this
distance we utilize a relay counting system having at least four banks of
relays with ten relays in each bank. The relay banks are set up by the computer JL first and
arms 122 riding in and out of predetermined slots which lock the/second relay
in the first bank closed (to represent the digit 2 or the 2 inches of the JL 1-
JL number 2.357) , the JL 1- 3rd relay in the second bank ,the 5th relay in the third
JL ban and the JL 1- 7th relay in the fourth bank, thus setting up the number 2.357
in the relay banks. The relays are so interconnected that when the motor Mx
has rotated 2000 times the second relay in the first bank will have been open-
ed therebye throwing the counting circuit into the second bank,each of said
master relays therein counting 100 revolutions and with each 100 opening the
first,second and third relay therein respectively ; upon the opening of the
third relay of the second bank closing the circuit with the fourth bank,etc.
until all four banks have been gone thru and the number 2.357 has been counted.
When the third bank of relays is operating,which counts one hundredths of
an inch of motion of the tool or tens of revolutions, a switch is automat-
ically thrown which is in circuit with means slowing down the speed of
the motor driving the tool to a fraction of its normal speed therebye

to be stopped more precisely at the desired travel distance as the Fourth bank of switches runs out. The employment of banks of said counting switces to control the revolutionary travel of a serve motor is known to the art and may not only utilize electro mechanical relays buy also electonic counting circuits.

The following example is presented to illustrate a possible sequence of operation of the components of Fig. 21. The card or tape 119 driven by motor 125 starts motion relative to the feeler elements 122 (FMx, FMz, FMx, (-FMx, -FMy, -FMz, etc. (not shown) by representing circuits associated with the computor 9 47 for commanding reversing the motors Mx and Mz, etc. when needed) Motor Mx is started up and travels along the overhead track to the first station. If it is desired to stop the conveyor unit at the first station, the switch 59 may be employed and may be actuated to brake the carriage 22 or stop the motor as in 13 Fig. 5. Assuming that it is desired to stop at a station, the feeler element FMx' is employed. FMz' rides into a hole 124 in the card 119 closing switch SMx' which closes a circuit with the power supply and motor Mx the switch 59 which is normally closed. With the closing of SMx', F Mx rides out of a hole in the card, SMx opens, therebt opening its circuit with Mx and the power supply and permitting Mx to be stopped when switch 59 is opened by the station locator pin 62 or by the photo-electric relay of Figs. 7 and 8. Switch 59 may be a dual switch which actuates solenoid 65 at the same time it opens the circuit with Mx. Said solenoid 65 may be used to brake the motor Mx or stop the conveyor unit precisely at the station as in Fig. 6. The actuation of 59 at the station may also close a circuit with My and the power supply to drive the platform 75 towards the machine bed 71 until it (58) strikes the stop S or end of the machine bed, thereby opening platform end switch 89 upon contact with S and stopping My. Or, a circuit comprising a switch SMy actuated to close by a feeler arm FMy may permit My to drive the platform to said machine bed 71 which is either stopped thereat by FMy riding out of its card slot 124 or by 89' in a manner similar to that by which 59 stopped Mx. Actuation of the machine tool mechanism may be initiated by limit switches SW closed by the motion of the platform towards the machine as in Figs. 9 to 11, or by signals from computor 47 thru the electrical coupling of Fig. 14.

When the elements FMx, FMy, FMz, etc. drop into cutouts 124 in the card 119, they complete circuits thru the coupling means of Fig. 14 with a powersupply and MTx, MTy, MTz. etc. and may be utilized to command the actions of the tool respective to the work. Thus 47 may be used to control tool motion, feed, speed, etc.

Variations of this arrangement may be utilized (such as the placing of easily adjusted or changeable command devices at each tool which are started by limit switches actuated by motion of the conveyor or by the command device 47 at the conveyor unit).

When the machine tool MT has completed its operation on the work, the motion of the tool in withdrawings from the work may be utilized to effect release of the work from the machine tool clamps MTBC, etc. or this action may be accomplished by signals from 47 at the proper time. The action also initiates withdrawal of the conveyor unit from the machine by the starting of My in reverse to effect said withdrawal to the aisle station position. Again, the withdrawal may be attained under command from 47. When the work platform has returned to its aisle position, My stops either automatically by the use of a limit switch or under command of 47. The stopping of My may be utilized to start up Mx to drive the conveyor unit along to the next station, etc. While the schematic drawing (fig. 21) is not complete for those setups (such as just described) involving the use of limit switches (at the platform or machine tool actuated by the motion of either relative to each other or to itself) to start and stop motions of the conveyor unit, work W, work platform 35 or tool or for the purposes of initiating and ending other actions such as work release, working positioning, work turning, clamping, or other machine motions and operations, the electrical diagram would merely show a repetition or an elaboration of the switch (59) and computer control means used to control Mx and described above.

Summarizing the possible methods of automatic control as applicable to the automatic manufacturing components heretofore described, (a) the conveyor units described may be operated and controlled solely by the use of position detecting devices such as limit switches, photoelectrically operated switches, etc., (b) the entire sequence may be commanded by a computer such as 47, (c) the operation may be commanded in part by a computer such as 47 mounted on each conveyor unit, said computer continuously running and supplemented by actions actuated by position detection switching devices, (d) the operation may be commanded in part by a computer which runs intermittently, is stopped and started and supplemented by position detecting switching devices such as 59, 88, 89, SW, SW', etc., (e) the conveyor units described may be automatically moved from station, stopped and directed to the machines by the position detecting means described, clamped in a prepositioned attitude respective to the machine and operated on thereat under command of a station situated computer which is easily and rapidly changed as is 47.

applications

For those production applications requiring such a number of individual pre-determined command signals and where said signals would not all easily be put on a card as a series of cutouts, etc. the use of a tape is preferred. Figs. 21 and 22 show magazine loading tape arrangements for a punched or cutout tape and a magnetic tape respectively. These will save setup time and will be especially useful where there are a variety of products in production on the same line and the demand for each varies with time (viz: one or two parts may be automatically made without an expensive setup in the proposed systems, and the sequence command signals may be varied for each product by merely removing and replacing a magazine).

Fig. 22 shows a punched tape magazine and mounting. The magazine is a container having parallel faces 130 spaced apart by a rim wall 131 extending thereabouts save for an opening 132 exposing the punched tape 133 which winds around one end spool 134 to a second end spool 135 situated within the container. The tape thus extends perferally about the open face said of the container. The end spools 134 and 135 are rotationally mounted on bushing 136 or pins which are supported in bearing between the parallel faces 130 of the container. A series of rod like fingers 122 riding on the surface of the tape 133, each extend from a switch 123 mounted on a support 137 and are adjusted to actuate said switches, (i.e., electrically open or close them) whenever the finger ends drop into or are forced out of a cutout in said tape. Each of said switches is connected in series circuit with an electrical device associated with the production system and a power supply. The container 130 is easily mounted and removed from a base 137 so that the shaped end of the shaft 138 of a constant velocity motor 139 projects thru either of the bushings 136 on which end spools 134 and 135 are mounted and may turn said bushing with the rotation of said motor. The numeral 140 refers to a cylindrical roller (or rollers) mounted on a verticle shaft extending from base 137 which may be utilized to facilitate passage of tape 133 and to back or reenforce it in the areas where the feeler elements or fingers 122 ride thereover. If the roller is utilized, the cutout section 132 of the container must, of necessity, be large enough to permit its free rotation. An alternative is to rotationally fasten the roller between the parallel walls of the casing opposite or adjacent to the opening 132 as shown. The numeral 139' refers to a second servo motor which may be also mounted on 137 to reverse the direction of travel of 133 for rewinding. The two motors 139 and 139' may be replaced by a single motor or a solenoid adapted to move the tape 133 a brief interval each time it is actuated.

Fig. 23 is an isometrci partial view of a modified design of the magazine of Fig. 22 The aforedescribed punched tape 133 has been replaced by a tape 133' with a magnetic recording thereon, which winds from one reel 134 mounted within the casing ~~to within~~ onto #2 another reel 135 also mounted therein. The magnetic tape 133' is thus totally enclosed save for an opening 132, which extends across one edge from the surface 130 to 130'. As such, the conventional magnetic pick-up mechanism comprising ,in part the drum 144 may be passed thru the opening 132 in the act of mounting the magazine on the base 137 which serves as a backing and positioning device for the magnetic tape and is part of the pick-up mechanism working with the pick-up head 142 which is positioned there-opposite. As the pickup head 142 must either make contact with or be positioned just off the surface of the tape 142 , it (142) is mounted on a projecting base 143 which is slidable mounted on guides 143' extending from base 137 and is spring mounted via compression spring 145 (engaging 143) to load 142 against the tape or to a position just off the tape. In mounting the magazine the pickup head mount 143 is withdrawn compressing spring 145 and permitting 133' to be passed between 144 and 142 without injury. The base mountedtstops 146 and then utilized to clamp the magazine casing in place. The shaft 138 of the servo motor or servo device 139 is then engaged with either or both of the reel bushings 138' or may be spring loaded axially to automatically engage said bushings when the magazine is slipped into place/ This may be accomplished also by merely mounting the magazine so that it is over and engaged by the perojecting ends of engaging and driving mechanism, the design prosented only to illustrate the fact that a servo device or motor engages the shaft of the reels. 7/1/